GeoPotential
ENVIRONMENTAL & EXPLORATION GEOPHYSICS
437 N.E. LIBERTY AVE. GRESHAM, OR 97030 • PH (503) 665-7520 • FAX (503) 492-4404
E-MAIL GeoPotential@aol.com

SUMMARY REPORT

SUBSURFACE MAPPING SURVEY
FOR
GRAVES

POOR-FARM CEMETERY
NE 68TH STREET, WEST OF HAZELDELL PARK
VANCOUVER, WASHINGTON

CLIENT:

JD White Company
1111 Main Street, Suite 300
Vancouver, Washington 98660

August 17, 2004

GeoPotential Project Number 7107

CONTENTS

FIGURES

APPENDICES

SUMMARY

A geophysical survey was conducted at the poor-farm cemetery located on NE 68th Street, west of the Washington State University (Vancouver) agricultural sciences facility, inVancouver, Washington (Figure 1) for the purpose of determining its boundaries. A Ground Penetrating RADAR (GPR) survey was conducted to achieve the project's objective.

Several graves were detected with the radar survey. The highest concentration of graves was encountered at and near the top of the hill around the existing cemetery monument, as well as along the western cemetery boundary. More graves were detected to the east and south of the high-concentration group.

INTRODUCTION

Subsurface mapping surveys are geophysical surveys utilizing geophysical data and methods to detect and locate natural and manmade subsurface features. Surveys using GPR are often used to help locate subsurface objects or disturbed-soil zones, such as UST pits or graves.

SURVEY OBJECTIVES

The survey objective at this site was to map the extent of the old poor-farm cemetery west of the WSU agricultural facility in Vancouver, Washington.

SURVEY SITE

The survey site consisted of the grass-covered burial ground between residential lots to the west, and the WSU agricultural sciences facility to the north and east. The surface sloped up from NE 68th Street, reaching the top at its northernmost boundary, where a monument marked the significance of the site. Only one headstone was present, but up to 200 graves were reported to exist at the site. A fence line marked the eastern and northern edges, residences were on the other side of an old fence on the western edge close to NE 98th Street, and a wooded area was located to the northwest.

TIMING

Jeff Mann and Nikos Tzetos of GeoPotential conducted fieldwork on August 13, 2004. Karyn Criswell of the JD White Company was present on site for the beginning of the survey. The report was written by Nikos Tzetos and emailed to JD White Company on August 18, 2004.

SURVEY EQUIPMENT

The following geophysical instruments were used to conduct the survey:

- MALA RAMAC GROUND PENETRATING RADAR SYSTEM with a 250 MHz ANTENNA (GPR SURVEY)

This equipment and the procedures used to meet the survey objectives of this project have been proven effective in detecting buried objects and disturbed-soil zones.

The success of a GPR survey is greatly controlled by site conditions. Clayey-soil, wet-soil conditions and reinforcement, severely attenuate signal penetration even at different locations on the same site. Features and objects may be missed if they are deeper than the signal penetration, or if they are located under metallic debris or utilities.

PROCEDURE

Since the objective of this project was not to mark individual graves, it was decided to scan the area with GPR, starting from the center and moving outwards, up to the point where no more graves were evident. Only one profile was acquired in the wooded area west of the monument, because of the dense ground cover. Since possible graves were detected just west of the WSU fence line, the survey was continued east of it to determine if the cemetery extended there.

In GPR surveys, high frequency electromagnetic energy is transmitted into the ground from a transmitting antenna. Soil electrical properties affect the propagation of the radar signal. When this energy encounters an inhomogeneity in the electrical properties of the soil, part of it is reflected back to a receiver antenna, and part of it continues its downward travel. The reflected signal is processed and displayed. Numerous such traces are placed side by side forming a "profile", or two-dimensional cross-section that is usually a plot of horizontal distance versus two-way travel time. If the velocity of the signal in the soil is known exactly, this travel time can be converted to true depth. In most cases, depth is an educated estimate from assumed ground velocities.

A GPR survey designed to locate disturbed-soil zones depends on the differences in signal response between an undisturbed area and a disturbed, or dug area. As the antenna travels from above the undisturbed soil to above the disturbed area (grave in this case) on the ground surface, it will produce a profile displaying continous "layers", next to disturbed, broken-up "layers" that sometimes penetrate deeper. This change point is mapped as the beginning of the disturbed-soil zone.

RESULTS

Figure 2 is a site diagram, showing the extent of the cemetery. Two zones of grave concentration were detected. The first, a high-concentration zone, that contains numerous well-defined graves, is located at the top of the hill around the monument and lines the western edge of the cemetery next to the residences, as far south as the place where the driveway up to the cemetery widens. A second, lower-concentration area is located east of the first zone, up to the WSU fence, except in one location, where it extends beyond the fence. Based on the profile taken inside the wooded area to the northwest of the site, the cemetery terminates at the tree line west of the monument.

Figure 3 is an example of a GPR profile over a group of graves.

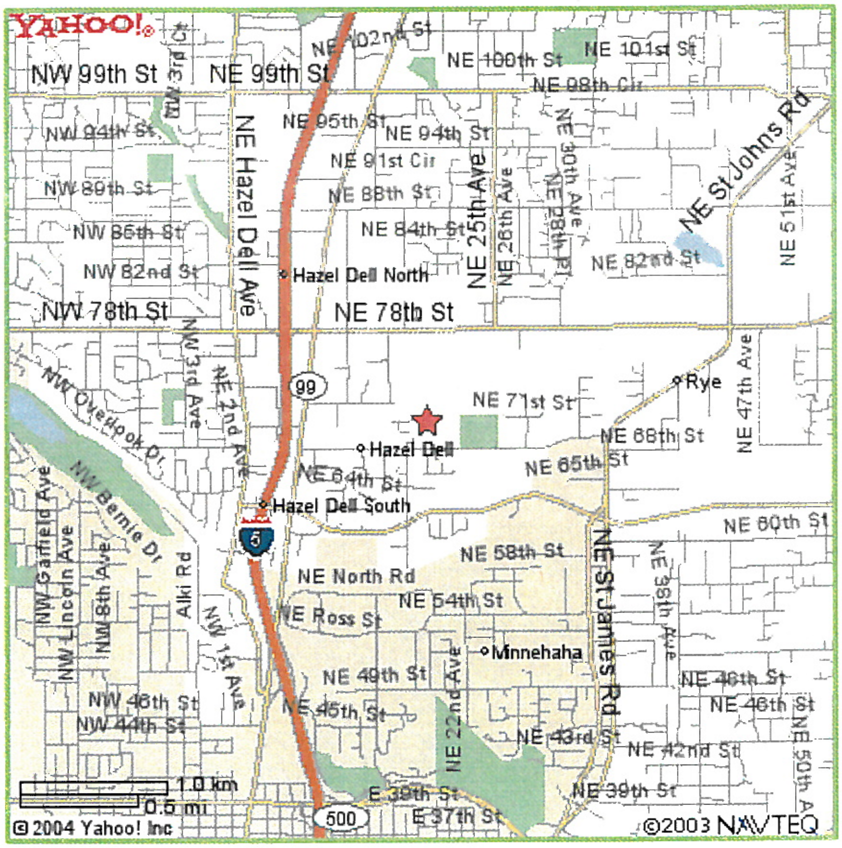
LIMITATIONS

Geophysical surveys consist of interpreting geophysical responses from subsurface features. Since a variety of subsurface features can produce identical geophysical responses, it is necessary to confirm the geophysical interpretation with intrusive investigations such as excavating or drilling. In addition, many subsurface features may produce no geophysical response. The use of this subsurface mapping survey is the sole responsibility of the client.

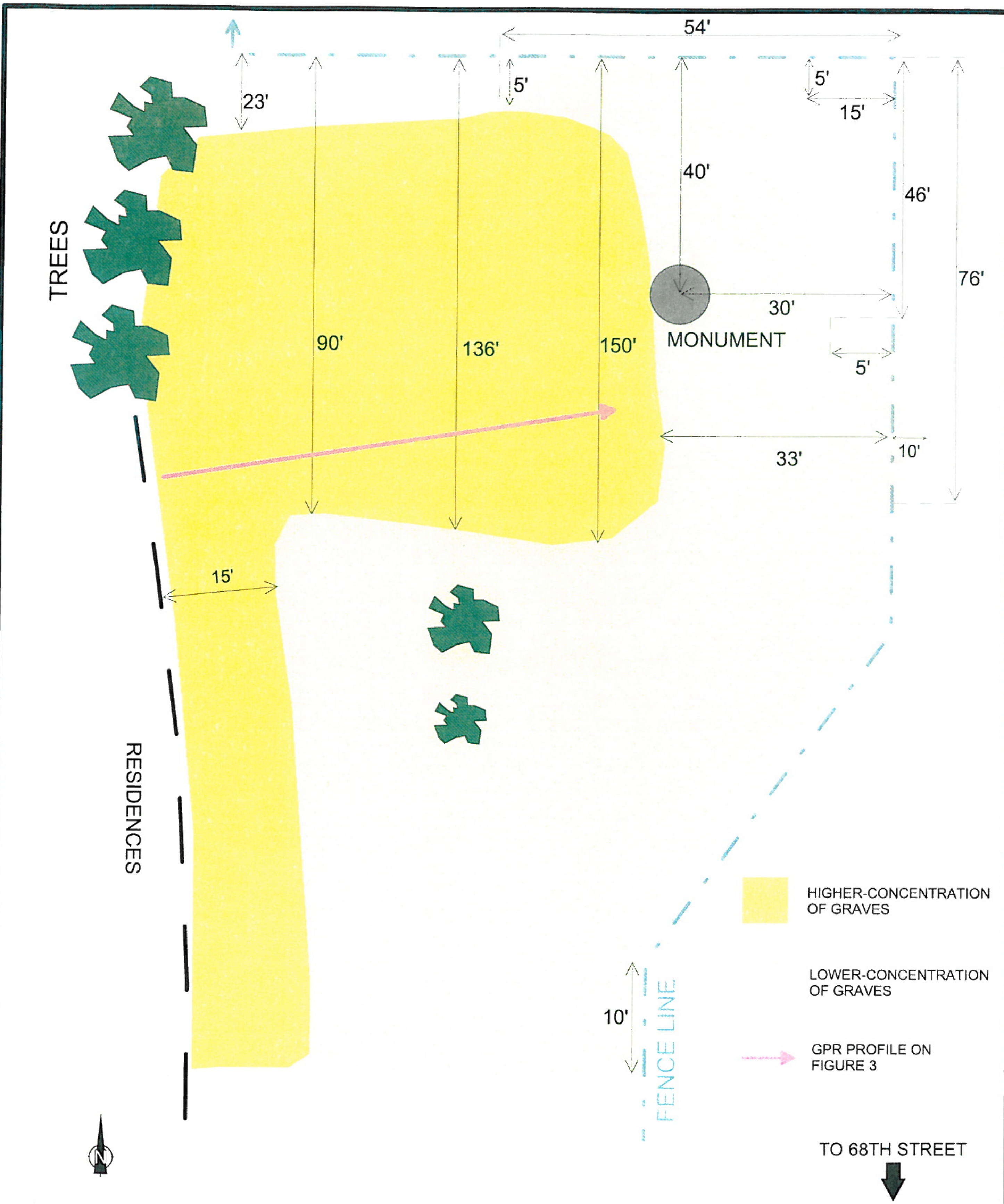
Ralph Soule
GeoPotential

Nikos Tzetos
GeoPotential

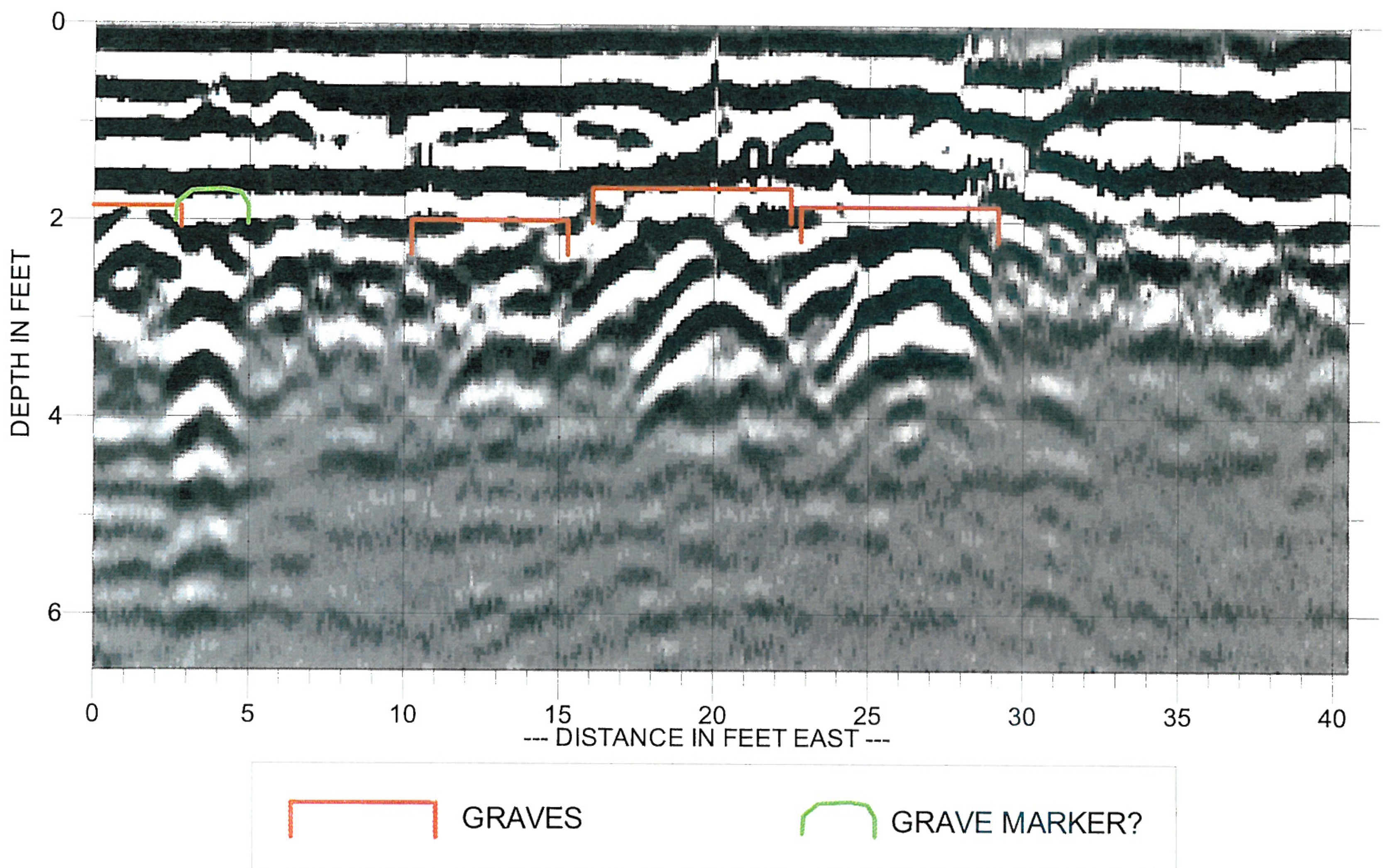
August 18, 2004



GeoPotential ENVIRONMENTAL & EXPLORATION GEOPHYSICS 437 N.E. LIBERTY AVE. GRESHAM, OR 97030 · PH (503) 665-7520 · FAX (503) 492-4404 E-MAIL GeoPotential@aol.com	LOCATION: POOR-FARM CEMETERY NE 68th Street East of Hazeldell Park Vancouver, Washington	**FIGURE 1. LOCATION MAP**	
DATE: August 13, 2004 · *SUBSURFACE MAPPING SURVEY* · PROJECT No. 7107	CLIENT: JD White Company		



GeoPotential — ENVIRONMENTAL & EXPLORATION GEOPHYSICS 437 N.E. LIBERTY AVE. GRESHAM, OR 97030 · PH (503) 665-7520 · FAX (503) 492-4404 E-MAIL GeoPotential@aol com	LOCATION: POOR-FARM CEMETERY NE 68th Street East of Hazeldell Park Vancouver, Washington	**FIGURE 2.** **SITE DIAGRAM** **(NOT TO SCALE)**
DATE: August 13, 2004 *SUBSURFACE MAPPING SURVEY* PROJECT No. 7107	CLIENT: JD White Company	



GeoPotential

ENVIRONMENTAL & EXPLORATION GEOPHYSICS

437 N.E. LIBERTY AVE. GRESHAM, OR 97030 · PH (503) 665-7520 · FAX (503) 492-4404
E-MAIL GeoPotential@aol.com

DATE: August 13, 2004 | *SUBSURFACE MAPPING SURVEY* | PROJECT No. 7107

LOCATION:
POOR-FARM CEMETERY
NE 68th Street East of Hazeldell Park
Vancouver, Washington

CLIENT: JD White Company

FIGURE 3.
GPR PROFILE

APPENDIX A
GROUND PENETRATING RADAR SURVEYS

Ground Penetrating Radar (GPR) can be a valuable tool to accurately locate both metallic and non-metallic USTs and utilities, buried drums and hazardous material at some sites. It may detect objects below reinforced concrete floors and slabs. GPR may delineate trenches and excavations and, under some conditions, it may be used to locate contaminant plumes. It has been used as an archaeological tool to look for buried artifacts. It may accurately profile fresh water lake bottoms either from a boat or from a frozen lake surface. GPR may be used to locate voids below roads and runways. GPR has numerous engineering applications. It can be used in non-destructive testing of engineering material, for example, locating rebar in concrete structures and determining the thickness of concrete and other structural material.

GPR uses short impulses of high frequency radio waves directed into the ground to acquire information about the subsurface. The energy radiated into the ground is reflected back to the antenna by features having different electrical properties to that of the surrounding material. The greater the contrast, the stronger the reflection. Typical reflectors include water table, bedrock, bedding, fractures, voids, contaminant plumes and man-made objects such as USTs and metal and plastic utilities. Materials having little electrical contrast like clay and concrete pipes may not produce strong reflections and may not be seen. Data are digitally recorded or downloaded to a laptop computer for filtering and processing.

The frequency of the radar signal used for a survey is a trade off. Low frequencies (250 MHz – 50 MHz) give better penetration but low resolution so that pipes and utilities may not be seen. Pipes and utilities may be seen using higher frequencies (500 MHz) but the depth of penetration may be limited to only a few feet especially in the wet, clayey soils found in the northwest USA. The GPR frequency is dependent upon the antenna. Once an antenna is selected, nothing the operator can do can increase the depth of penetration.

Radar data is ambiguous. Many buried objects produce echoes that may be similar to the echo expected from the target object. Boulders and debris produce reflections that are similar to pipes and tanks. Subtle changes in the electrical properties along a traverse caused by changes in soil type, mineralogy, grain size, and moisture content all produce "noise" that can make interpretation difficult. Interpreting radargrams is an art as much as a science.

Under some conditions, although a UST itself may not be clearly visible in a GPR record, the excavation or trench in which the UST is buried is evident. Usually GPR data is used to compliment data from other "tools". For example, a trench-like reflection but no clear UST reflection, combined with a "tank" shaped magnetic anomaly suggests the presence of a UST. Although the UST itself could not be seen using GPR, the radar showed a trench-like reflection. The magnetic data showed a large ferrous object. We would report a possible UST at that location.

GPR is often used in conjunction with magnetometer surveys. Magnetometer Surveys are very fast and large areas can be covered cost-effectively. Magnetic anomalies are marked in the field, and then may be further investigated using radar.

GPR, like other geophysical tools, is excellent at detecting changes across a site, but it is poor at actually identifying the cause of the change. **The only sure way to identify buried objects is through excavation.**

ADVANTAGES - General

GPR provides continuous records along traverses which, depending on the goal of the survey, may be interpreted in the field.

At flat, open sites, for reconnaissance purposes, the antenna can be towed behind a vehicle at several mph.

Many GPR antennas are shielded and are unaffected by surface and overhead objects and power lines.

GPR can be used in conjunction with magnetic or EM surveys to accurately locate buried objects.

ADVANTAGES – Site specific

With a low frequency antenna, in clean, dry, sandy soil, reflections from targets as deep as 100 feet are possible. Geologic features such as bedrock and cross bedding may be seen at some sites.

The resolution of data is very high particularly for high frequency antennas.

Shallow, man-made objects generally can be detected.

Fiberglass USTs and plastic pipes can be detected using GPR.

LIMITATIONS - General

To acquire the highest quality data, proper coupling between the antenna and the ground surface is necessary. Poor data may be obtained at sites covered with debris, an uneven surface, tall grass and brush. Objects located at curbs are difficult to see.

Acquiring GPR data is slow. The antenna must be over the target. The signal from the antenna is cone-shaped. Reflections from objects to the side of the antenna may be seen, but their actual location relative to the antenna is not obvious.

Penetration of the GPR signal is "site-specific" and its depth of penetration at a particular site cannot be predicted ahead of time. Near surface conductive material, such as salty or contaminated ground water and wet, clay-rich soil, may attenuate the radar signal, limiting the effective depth of the survey to a few feet. Objects below the depth of penetration cannot be seen in most cases. Reinforced concrete also can attenuate the signal. Rebar may produce reflections that look like pipes.

GPR may not be cost-effective for some projects. For a detailed survey mapping underground storage tanks and utilities, it may be necessary to collect data in orthogonal directions at 5-foot line spacing.

LIMITATIONS – Interpretation

Interpretation can be difficult. Radar data are ambiguous. Subsurface objects can be detected but, in general, they cannot be identified. USTs and utilities have a characteristic reflection, however, large rocks and boulders have a similar reflection.

The reflection visible in a GPR record is very complex and may be caused by small changes in the electrical properties of the soil. The target in mind may not produce the reflection. Due to "noise", the target may be missed. USTs and deep utilities may be missed if they are under debris and/or other pipes.

Other methods may be necessary to aid in the interpretation of the data (use a magnetometer to detect a large metallic mass, then GPR to determine if the object is tank-like, or utility locating equipment to determine if there are feed lines and fill pipes leading to the object).

Adequate contrast between the ground and the target is required to obtain reflections. USTs may be missed if they are badly corroded. Utilities made of "earth" materials like clay and concrete may not be detected since their electrical properties are similar to the surrounding soil.

To determine the depth to an object without "ground truth", assumptions must be made regarding soil properties. Even with ground truth at several locations on the same site, changes in material across a site (therefore changes in signal velocity) can cause errors in depth measurements at other locations.